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REVIEW OPEN ACCESS

Links Between Western Diet and The Human Gut Microbiome: A Literature Review

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Abstract

Introduction: The human gut microbiome plays a crucial role in maintaining health by influencing immune function and metabolic processes. Diet is a major factor in shaping microbiome composition and can be linked to a range of chronic diseases. This systematic review examines how the Western diet alters gut microbiome composition and its subsequent effects on inflammation, metabolism, and immune health.

Methods: This review synthesizes findings from thirteen studies examining the impact of the Western diet on gut microbiome composition and related health outcomes. The review analyzes these studies to identify key mechanisms linking diet to microbiome changes and immune function, while highlighting gaps in current research.

Results: The review found that the Western diet leads to significant alterations in gut microbiome composition, including reduced microbial diversity and an imbalance in inflammatory responses. These changes are linked to the development of metabolic and immune diseases, such as obesity, type 2 diabetes, and inflammatory bowel disease. Diets such as the Mediterranean diet promote a more diverse and stable microbiome, with associated improvements in immune function and reduced disease risk.

Discussion: This review highlights the need for further research on how diet shapes gut microbiome composition and its impact on immune and metabolic health. The Western diet's disruption of microbial diversity and its promotion of inflammation contribute significantly to the rise of chronic diseases. In contrast, diets, such as the Mediterranean diet, appear to support a healthier microbiome and reduce disease risk through their anti-inflammatory and microbiome-supporting properties. Gaps remain in understanding the causal mechanisms behind diet-microbiome interactions, and further research is needed to explore personalized dietary interventions for disease prevention and optimal gut health.

Conclusion: This review underscores the importance of diet in influencing gut microbiome composition and its role in immune and metabolic health. The findings suggest that dietary interventions may offer effective strategies to mitigate the negative effects of the Western diet on health. Future research should focus on understanding the causal mechanisms of diet-microbiome interactions and developing personalized nutrition approaches to improve gut health and prevent chronic diseases.

Keywords: gut microbiome; western diet; metabolic; immunity; disease risk; bacteria; microbiota; non-communicable disease; Mediterranean diet

Introduction

The human gut microbiome is composed of billions of microorganisms that create a symbiotic relationship with humans, and which are influenced by various external and internal factors [1]. Dietary habits play a key role in the composition and diversity of the microbiome. Our diets have become increasingly recognized as an underlying cause for various diseases and conditions such as coronary heart disease, obesity, type 2 diabetes, osteoporosis, and autoimmune diseases. The Western diet, characterized by high intakes of processed foods, unhealthy fats, and sugars, has been linked to various chronic diseases [2]. While most of these foods are widely recognized as being harmful to human health, there is limited understanding regarding their specific impact on our microbiome composition and the links between our diet, microbiome, and the causes of various diseases [3].

This review aims to provide further insight into how Western diets, compared to other diets such as the Mediterranean diet, impact and alter the composition of the human gut microbiome. Our diet plays a major role in shaping host immune function and the gastrointestinal microbiota [2]. The overabundance of calories and certain macronutrients that compose today's modern diets have been accompanied by an increase in levels

of obesity, and may lead to increased inflammation, increased metabolic diseases, and increased risk for allergic and auto-inflammatory disease [2,3]. These combined factors have led to a point wherein chronic immune activation that arises from Western lifestyles has begun to take a toll and shorten the lives of following generations [5]. Immediate action in the form of prevention must be taken to reverse the trends we are witnessing in our societies.

This systematic review will analyze the mechanisms of how the microbiota impacts human health and discuss the gaps in our knowledge surrounding the links between the Western Diet and the human microbiome. These findings will further shed light on the relationship between the microbiota and the host, which will provide researchers with further information surrounding ways to target interventions that improve immune health and protect the public from health burdens associated with the Western diet.

Methods

This review is based on 13 peer-reviewed papers identified using key terms related to the Western diet, microbiome, and related health outcomes. To ensure accuracy and relevance, the oldest paper I included in this review was published in 2007. The papers selected were deemed to be best suited for the review and provided the most valuable and informative discussions on the Western Diet, the human microbiome, and immune health. These papers discuss a variety of topics such as the links between long-term dietary patterns and the gut microbiome, the connections between the Western diet and the immune system, comparisons between the Western diet and the Mediterranean diet, the role of microbiome-host interaction in metabolic disease, and many more. Various topics of research were chosen to be discussed throughout this review, and multiple of the studies were used for further analysis in the results and discussion sections. First, a description and general information surrounding the Western diet is provided, followed by highlighted gaps that exist in our current understanding. Second, the human microbiome and the host-microbiota relationship is discussed. Third, the specific impacts of the Western diet on the microbiome and how they lead to inflammation and further to immune and metabolic diseases is reviewed. Fourth, the Western diet is compared to the Mediterranean diet and their effects on human health are discussed. Finally, the implications of research surrounding the relationship between diet, the human microbiome, and immunity are reviewed, and suggestions about ways we can prevent the health issues that arise from this relationship are provided.

Results

Current Understanding and Highlighting the Gaps in Our Knowledge of the Western Diet

Recent increases in chronic inflammatory diseases (NCDs) in Western societies have been linked to lifestyle and diet changes, particularly the rise of the Western Diet [5]. This diet high in processed foods, refined sugars, salt, and fats, but low in fiber, vitamins, and antioxidants, contributes to poor health outcomes, including obesity and metabolic diseases [5]. Fiber lowers the glycemic index of food by slowing down the carbohydrate uptake and hindering the absorption of dietary lipids and cholesterol [5]. Various foods including vegetables, fruits, legumes, and whole grains are abundant in fibers [5].

Western diets are energy and calorie-dense and provoke a fast rise in blood glucose, causing a high-calorie intake over short periods with rapid spikes in plasma glucose and insulin levels, leading to the absorption of nutrients into adipose tissue, otherwise known as body fat [5]. This excessive intake of calories has been argued to drive the obesity epidemic [3]. While the impacts of the Western diet cannot be considered in isolation, this review highlights the links between diet and health.

A study that was conducted on the temporal variability of the human microbiome found evidence for individual variation in the relative abundance of taxa, with some individuals maintaining more variable communities within their microbiome than others. These findings can be best explained by microbial diversity, given that individuals with a more diverse gut community have a more stable composition than those with less diversity [7]. However, even small variations in research methods such as sampling, storage, deoxyribonucleic acid (DNA) extraction, and data analysis will have substantial effects on results and findings [6]. Even strong associations between diet, the microbiome, and NCDs do not establish causality. Gaps in our current knowledge of the links between diet and microbiome composition are due to a lack of longitudinal studies starting with early life exposure to various diets. Currently, there is a shortage of studies surrounding the ability to modify the microbiota via specific dietary interventions [6]. These gaps in knowledge must be filled to develop successful preventative measures. To fill these gaps, future studies should focus on addressing broader dietary patterns rather than individual dietary components, longitudinal studies researching early life exposure to various diets, evaluating the ability to modify the microbiota by dietary interventions, risks associated with the consumption of processed foods, and establishing causality between diet, microbiome, and various immune diseases.

Human Microbiome and Host-Microbiota Relationship

The human gastrointestinal tract hosts more than 100 trillion bacteria, archaea, and eukaryotes which function together to form the gut microbiota and create a symbiotic relationship with the host [8]. While the term ‘microbiome’ refers to the entire habitat of microorganisms that inhabit the gastrointestinal tract (GI), ‘microbiota’ are the microbes residing within a specific habitat of the body, such as the GI [1]. Disequilibrium or alterations in compositions of the gut

ecosystem, known as dysbiosis, have been shown to result in various metabolic and immune diseases as compared with healthy subjects. These include inflammatory bowel diseases, irritable bowel syndrome, obesity, diabetes, and various other NCDs [8]. Many of the microbes found within the gut microbiome can be classified into five different phyla including: *Firmicutes*, *Actinobacteria*, *Bacteroidetes*, *Proteobacteria*, and *Fusobacteria* [1]. The host and the microbiome have a symbiotic relationship in which the gastrointestinal microbiota perform essential functions in the host, and the components of our diet, our environment, and intake of antibiotics have the capability to both directly influence our immune cells and alter gut microbial composition [2].

In a comparative study done on the association between microbiota and different diets in human populations, researchers compared the fecal microbiota of 15 healthy European children (EU) living in the urban area of Florence, Italy, with that of 14 healthy children from the Mossi ethnic group living in the village of Boulpon in Burkina Faso (BF), a country in rural West Africa. The BF individuals had a diet which was higher in starch, fiber, carbohydrates, and plant polysaccharides, but lower in fat and animal protein compared to the EU individuals. The researchers found that the BF children had higher levels of microbial richness than that of the EU children [9].

The researchers characterized the bacterial lineages present in the fecal microbiotas and found that *Firmicutes* were twice as abundant in the EU children, which they argue is evidence of a significantly different bacterial colonization of the human gut between the two populations [9]. Additionally, *Prevotella*, *Xylanibacter* (Bacteroidetes) and *Treponema* (Spirochaetes) were only found in the microbiota of BF children, which they hypothesize is a result of high fiber intake. They argue that the reduction in microbial richness seen in the EU samples is a possible effect of globalization combined with the consumption of generic and uncontaminated foods, whereas exposure to a variety of environmental microbes and a high-fiber diet may increase the beneficial bacterial genomes found in the BF diet and enrich the microbiome [9]. The reduction in richness observed in EU compared to BF children suggests that the increase in consumption of sugar, animal fat, calorie-dense, and processed foods in Western diets is limiting the adaptive potential of the microbiota [9]. These results suggest that we should prioritize diets that maximize energy intake from fibers, and which protect us from inflammation and metabolic diseases.

Western Dietary Habits and their Influence on the Gut Microbiome

The Western diet, high in saturated fats from red meet, processed foods, and dairy, triggers immune system inflammation [5]. Saturated fats are found in foods such as red meat, certain oils, processed foods, and dairy, whereas avocados, nuts, olive oil, and fish are examples of unsaturated fats. Both saturated and unsaturated fatty acids affect immune cell homeostasis and gut microbiome composition though the exact links remain unclear.

High-fat diets lead to impaired functions of insulin action and the regulatory mechanisms of body weight [10]. Researchers attempted to determine the effect of a high-fat diet on the occurrence of plasma lipopolysaccharides (LPS) concentration in high-fat diet-fed mice [10]. LPS is a large molecule that can cause inflammation, lead to metabolic syndrome, and increase the risk of heart disease and diabetes. The findings of this study suggests that higher levels of LPS may dysregulate the inflammatory tone and lead to weight gain and diabetes [10]. The researchers found that the maintenance of the mice on a high-fat diet for 4 weeks resulted in a notable modulation of dominant bacterial populations in the intestinal microbiota, and further chronically increased plasma LPS concentration, known as endotoxemia, by two or three times [10]. To demonstrate a causal link between high-fat diet-increased plasma LPS concentration and metabolic diseases, they induced endotoxemia in normal mice. Their findings showed an increase in fasted glycemia and insulinemia and whole-body, liver, and adipose tissue weight gain that was similar to that observed in high-fat-fed mice [10]. They also identified bacterial LPS as a triggering factor of metabolic disease and determined that metabolic endotoxemia dysregulates the inflammatory tone and leads to weight gain and diabetes. They suggest that lowering plasma LPS concentration could be a method of controlling the development of metabolic diseases. Key strategies to reducing plasma LPS concentrations include focusing on certain dietary changes like increasing intake of fiber, fruits and vegetables, healthy fats, and limiting saturated fat [10].

Comparison of the Western Diet to the Mediterranean Diet

The Mediterranean diet (MD) emphasizes foods such as virgin olive oil, vegetables, fruits, whole grains, fish, and plant-based proteins, with low red meat intake [11]. Studies show MD is linked to lower rates of cancer, obesity, type 2 diabetes, cardiovascular disease, and inflammatory conditions like Crohn's disease [12,13]. The MD additionally helps reduce inflammation by increase micronutrient intake and avoiding pro-inflammatory foods common in the Western diet, such as processed meats, refined grains, and fried foods [12].

A study in Italy found that individuals following vegetarian or vegan diets had higher adherence to the MD, with these diets increasing fiber intake, promoting gut microbiota diversity, and enhancing short-chain fatty acid (SCFA) production. In contrast, omnivorous diets, with lower fiber, resulted in less microbiome diversity [12]. Diets high in fiber act as prebiotics that nourish the gut microbiota and help create diversity of bacterial residents in the gut [12]. Plant-based diets are high in plant proteins, fruits, vegetables, and legumes that help to increase the diversity of the human glut flora and the volume of

bacterial metabolites such as SCFA. The researchers suggest that SCFA increase mucosal resistance against other pathogenic bacteria, which overall contributes to the health of the human host and provides protection from chronic conditions [12].

Higher adherence to the MD was also linked to lower urinary levels of trimethylamine oxide (TMAO), a metabolite associated with heart disease, kidney damage, and inflammation, which is produced from red meat and full fat dairy [12]. The researchers assert that the observed increase in fecal SCFA levels associated with higher consumption of fruit, vegetables, legumes, and overall adherence to the MD, is likely due in part to the presence of certain bacteria belonging to both Firmicutes and Bacteroidetes which can degrade carbohydrates that are not digestible by the host. While this study provides evidence that a Mediterranean diet supports microbiome health, omnivore diets can still be beneficial if they include adequate fruits, vegetables, and legumes [13].

Discussion

Medical Implications of Research

Recent research highlights the significant role of the gut microbiome in immune health, with the Western diet contributing to rising chronic diseases such as autoimmune disorders and IBD. Dietary manipulation in the form of various alternative diets such as the Mediterranean diet have offered promises of supporting microbiome health and autoimmune disorders such as inflammatory bowel disease (IBD) [6]. However, the efficacy of these diets together with their effect on the microbiota requires more research. Various ingredients that have experienced an increase in consumption within the Western diet include sweeteners, preservatives, food colourings, sucrose, and cereals. These products should be further investigated to provide information surrounding the effects of such ingredients.

In the studies discussed above that used mice to evaluate the links between inflammation and high-fat diets, researchers attempted to uncover a factor of microbial origin that would trigger and maintain a low-tone continuous inflammatory state. Their findings showed that diets high in fat increase plasma LPS at a concentration sufficient to increase body weight, diabetes, and inflammation levels. Moreover, these results show that lipids alone are not sufficient to promote obesity, and that LPS must also be considered as a newly identified inflammatory factor from microbiota. These findings suggest that lowering plasma LPS concentration could be a method of controlling the development of various diseases. While the MD shows promise in supporting microbiome health, further clinical trials are needed to evaluate its efficacy and the specific ingredients that influence microbiota composition.

Social Implications of Research

While many people are aware that modern western lifestyles can negatively impact the heart, kidneys, and weight, there is a lack of research and even larger lack of general knowledge surrounding its effect on the gut and immunity. The study comparing the microbiome of BF children to EU children suggests that diet plays a critical role over other possible variables such as ethnicity, sanitation, hygiene, geography, and climate, in shaping the microbiome. The results propose that the reduction in richness seen in the EU compared to BF children, could be a consequence of the increased consumption of sugar, animal fat, and calorie-dense foods in the Western Diet. The diversity of microbiomes across communities in the world, especially in situations where gastrointestinal infections can lead to severe illnesses or death, are a critical consideration for studies aiming to illuminate the role of the gut microbiome. The study does, however, contain certain weaknesses. The study includes only 29 children in total, which may not be large enough to generalize the findings to broader populations. Further, while the study presents associations between diet, microbiota composition, and health, it does not establish causality. Finally, the study is cross-sectional and does not allow for tracking long term changes between diet and the microbiome. Future studies aimed at uncovering associations between the microbiome, immunity, and human health should consider the influence of environmental, social, and microbial biodiversity. Furthermore, policymakers should consider these factors when making decisions surrounding public health and how our societies should be shaped more broadly.

Future Preventative Measures

While methods that target innate immune activation, trained immunity, or epigenetics are all future possible methods of intervention, the current focus should be placed on the prevention of immune and metabolic diseases. The earlier discussed study on the interconnection between Mediterranean dietary patterns, gut microbiota and microbial metabolites supports the claim that there are direct health benefits of adapting a MD. The results demonstrate a significant correlation between *Prevotella sp.* abundance and fruit and vegetable intake, and a higher level of *Prevotella:Bacteroides* ratio between the Italian subjects than is seen in other subjects. The researchers suggest that this is likely due to the higher fiber and starch intake in the Italian individuals. This research surrounding MD provides valuable insight into preventative measures achieved through our diet. In addition to the MD, research has shown that vegan, vegetarian, and high fiber diets act as prebiotics that contribute to the diversity of bacterial residents in the gut [12]. High-fiber and prebiotic diets which consist of fruits, vegetables, and plant-based proteins contain insoluble fibers which influence the growth of bacterial species and increase the content of microbiota [12]. Diets which prioritize a high intake of virgin olive oil, vegetables, fruits, plant-based proteins, whole grains, fish, low-fat dairy, and low red meat consumption can help to beneficially regulate the microbial metabolism towards a

host-microbe relationship that prevents immune and metabolic diseases [5].

Conclusions

This review underscores the critical role of the human gut microbiome in shaping immune function and metabolic health, with particular emphasis on how diet influences microbiome composition and disease. By examining the connections between diet, microbial diversity, and immunity, it highlights the importance of dietary interventions, such as the Mediterranean diet, in promoting a healthy microbiome and preventing disease. The findings suggest that future research should focus on understanding the causal mechanisms behind diet-microbiome interactions in human populations, as well as exploring microbiome-targeted interventions for disease prevention. Importantly, this study also raises new questions regarding the individual variability of microbiomes and the influence of environmental, genetic, and social factors on microbiome health. Future work should aim to identify specific dietary components that can optimize microbiome composition, further informing personalized nutrition and public health strategies aimed at reducing the global burden of chronic diseases.

List of Abbreviations Used

BF: burkina faso
DNA: deoxyribonucleic acid
EU: European
GI: gastrointestinal
IBD: inflammatory bowel disease
LPS: lipopolysaccharides
MD: Mediterranean diet
NCDs: non-communicable diseases
SCFA: short-chain fatty acid
TMAO: trimethylamine oxide

Conflicts of Interest

The author declares that they have no conflicts of interest.

Ethics Approval and/or Participant Consent

The work was a literature review that examined previous studies and articles. Therefore, no approval or participant consent was required.

Authors' Contributions

MGM: collected all the studies, articles and reviews, analyzed the data and interpreted it, drafted the manuscript, and gave final approval of the version to be published.

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References

[1] Patel P, Patel A, Chakraborty P, Gosai H. Impact of Dietary Habits, Ethnicity, and Geographical Provenance in Shaping Human Gut Microbiome Diversity. In: Probiotics, Prebiotics, Synbiotics, and Postbiotics. Singapore: Springer; 2023. p. 3-29. https://doi.org/10.1007/978-981-99-1463-0_1
[2] Las Heras V, Melgar S, MacSharry J, Gahan CGM. The Influence of the Western Diet on Microbiota and Gastrointestinal Immunity. Annual Review of Food Science and Technology. 2022 Mar 25;13(1):489–512. https://doi.org/10.1146/annurev-food-052720-011032
[3] Myles IA. Fast food fever: reviewing the impacts of the Western diet on immunity. Nutrition Journal. 2014 Jun 17;13(1). https://doi.org/10.1186/1475-2891-13-61
[4] Carrera-Bastos P, Fontes-Villalba M, O'Keefe J, Lindeberg S, Cordain L. The western diet and lifestyle and diseases of civilization. Research Reports in Clinical Cardiology. 2011 Mar;15. https://doi.org/10.2147/RRCC.S16919
[5] Christ A, Lauterbach M, Latz E. Western Diet and the Immune System: An Inflammatory Connection. Immunity. 2019 Nov;51(5):794–811. https://doi.org/10.1016/j.immuni.2019.09.020
[6] Sigall-Boneh R, Levine A, Lomer M, Wierdsma N, Allan P, Fiorino G, et al. Research Gaps in Diet and Nutrition in Inflammatory Bowel Disease. A Topical Review by D-ECCO Working Group [Dietitians of ECCO]. Journal of Crohn's and Colitis. 2017 Aug 10;11(12):1407–19. https://doi.org/10.1093/ecco-jcc/jjx109
[7] Flores GE, Caporaso JG, Henley JB, Rideout JR, Domogala D, Chase J, et al. Temporal variability is a personalized feature of the human microbiome. Genome Biology. 2014 Dec;15(12). https://doi.org/10.1186/s13059-014-0531-y
[8] Mondot S, Lepage P. The human gut microbiome and its dysfunctions through the meta-omics prism. Annals of the New York Academy of Sciences. 2016 Mar 4;1372(1):9–19. https://doi.org/10.1111/nyas.13033
[9] De Filippo C, Cavalieri D, Di Paola M, Ramazzotti M, Poullet JB, Massart S, et al. Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa. Proceedings of the National Academy of Sciences. 2010 Aug 2;107(33): 14691–6. https://doi.org/10.1073/pnas.1005963107
[10] Cani PD, Amar J, Iglesias MA, Poggi M, Knauf C, Bastelica D, et al. Metabolic Endotoxemia Initiates Obesity and Insulin Resistance. Diabetes. 2007 Apr 24;56(7):1761–72. https://doi.org/10.2337/db06-1491

[11] Schwingshackl L, Hoffmann G. Mediterranean dietary pattern, inflammation and endothelial function: A systematic review and meta-analysis of intervention trials. Nutrition, Metabolism and Cardiovascular Diseases. 2014 Sep;24(9):929–39. https://doi.org/10.1016/j.numecd.2014.03.003

[12] Niemeyer K, Buezo D, Landeros L, Corral K. Influence of Gut Microbiome on Obesity in Western-Style Dietary Practices Versus Other Diets: A Systematic Review . OSR Journal of Student Research. 2019;5(1). https://scholarworks.lib.csusb.edu/osr/vol5/iss1/353

[13] De Filippis F, Pellegrini N, Vannini L, Jeffery IB, La Storia A, Laghi L, et al. High-level adherence to a Mediterranean diet beneficially impacts the gut microbiota and associated metabolome. Gut. 2015 Sep 28;65(11):1812–21. https://doi.org/10.1136/gutjnl-2015-309957

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